National Park Service
Air Resources Division

Ozone Pollutant Monitoring in the National Parks

Gaseous Pollutant Monitoring Network Overview

To meet its general responsibilities with respect to air resource management, the Service has established an air quality monitoring network in 26 units of the National Park System. This network is used to determine the levels of gaseous pollutants, fine particles, and visual air quality occurring or affecting NPS units. The gaseous pollutant monitoring program has historically concentrated on determining the levels of two air pollutants, ozone and sulfur dioxide. These pollutants are particularly toxic to native vegetative species found in NPS units at levels at or below the National Ambient Air Quality Standards established by the Environmental Protection Agency (EPA) for these two pollutants. Other gaseous pollutants (e.g., other photochemical oxidants, nitrogen compounds, and toxic organic compounds) are also of interest to NPS because they relate to physiological, morphological, or histological injury to park biological resources, or to global climate change. Currently, only selected, limited studies measure other gaseous pollutants within the National Park System.

Design of the Network

The NPS gaseous pollutant monitoring network is comprised of two types of stations, trends and baseline. Trends stations are strategically located throughout the U.S. and maintained indefinitely to serve as the primary source of air quality information to guide NPS air resource management decisions. A fewer number of baseline stations are operated, the primary purpose being to document existing air quality levels for a short period (typically 3 to 5 years) after which time the stations are re-deployed to other NPS areas. The strategy is to establish existing conditions in nearly all 48 NPS class I areas by the year 2000 and to re-activate each of the baseline sites at 5 to 10 year intervals to determine whether air quality levels have changed from those measured when the area was monitored previously

Data from the trends network serve to characterize the spatial and temporal distribution and trends of key air quality indicators on a Systemwide basis. The data may

Primary Monitoring Objectives
Gaseous Pollutant Monitoring Program

- Establish baseline concentrations of air pollution in national parks
- Assess trends in air quality
- Determine compliance with national ambient air quality standards
- Provide data for the development and revision of national and regional air pollution control policies that are protective of park resources
- Provide data for atmospheric model development and evaluation
- Identify air pollutants which may injure or damage park natural resources, measure these pollutants, and correlate observed effects on resources to ambient levels of pollutants

also be used to influence environmental policy and regulation at the national, regional, and local level. From a design standpoint, the data from the trends network should be able to characterize the range of values for these air quality indicators, the extent to which these indicators are influenced by manmade activities (internal or external to the parks), and whether any observed changes are attributable to natural variation or to man-made activities. In order to characterize the range of air quality levels throughout the System, locations that are influenced from the emissions of urban areas, industrial source areas, or a combination of both, as well as areas with minimal influence from these sources, are monitored. To the extent possible, trend stations are representative of regional-scale air pollution levels within relatively large biogeographic areas.

Network Size. Network size is dependent on the diversity of air pollution emissions, the meteorology, the topography, the number of sensitive receptors, and the degree of spatial resolution required of an area. The NPS network needs to adequately characterize air quality levels in all ecoregions and at most of the NPS class I areas.

Existing Monitoring Networks. Another important design criteria to be considered is the availability of air pollution data generated by existing networks and the extent to which these data can meet NPS needs. Although the primary design criteria for state networks is population oriented, several states maintain remote stations to serve as "background" sites for these networks. In addition to these state networks, the U.S. EPA recently established a national network of dry deposition monitoring stations, mostly in the eastern U.S., however, under a joint agreement, 18 western sites are run cooperatively within National Parks.

Clean Air Act Designation. A park's designation under the Clean Air Act, e.g., class I area, is a major consideration in the NPS network design. Under the 1977 amendments to the Clean Air Act, 48 areas administered by the NPS (national parks, monuments, etc., larger than 6,000 acres and wilderness areas larger than 5,000 acres) were designated as class I areas affording them special protection under the Prevention of Significant Deterioration provisions of the Act.

The following factors were considered in the design of a trends network: (1) Clean Air Act designation; (2) potential changes in air quality; (3) existing air quality conditions; (4) ecological region representativeness; (5) park/regional priority; (6) park special designations; and, (7) participation in other NPS monitoring and research programs. These factors were evaluated for their relative importance with respect to air quality monitoring (in the context of network design) and were used to develop a numerical ranking procedure to facilitate the selection of trend sites. This procedure was applied to the largest NPS areas and the numerical score obtained for each of these areas was used to select trend stations.

Multiple Sites. Several parks (Sequoia, Shenandoah, and Yosemite) currently operate more than one station due to the biological effects studies being conducted at these parks. In general, it has been Division's policy to support only one station at each park using Servicewide Air Quality funding, however, when additional stations are required as part of biological effects studies being conducted at the park, the Division may fund additional sites at a park.

Parameter Coverage. Currently, the only gaseous pollutants monitored with continuous instruments in the network are ozone and sulfur dioxide, and several meteorological parameters. There are numerous other pollutants that affect resources within the Park System and that are of interest to the Service. At a minimum, each trends station should incorporate fine particle sampling using the IMPROVE protocols, wet deposition monitoring, and meteorological monitoring, and any other parameters currently monitored by the National Dry Deposition Network.

Ozone Monitoring Network Measurements

The current air quality monitoring sites within National Parks are given in the map below. Open diamonds indicate Class I parks where continuous ozone monitoring are yet to be done. Most of the current monitoring stations are located in Class I areas or Class II areas with significant air pollution problems.

Status of Ozone Monitoring in NPS Class I Areas
1996 - 1997

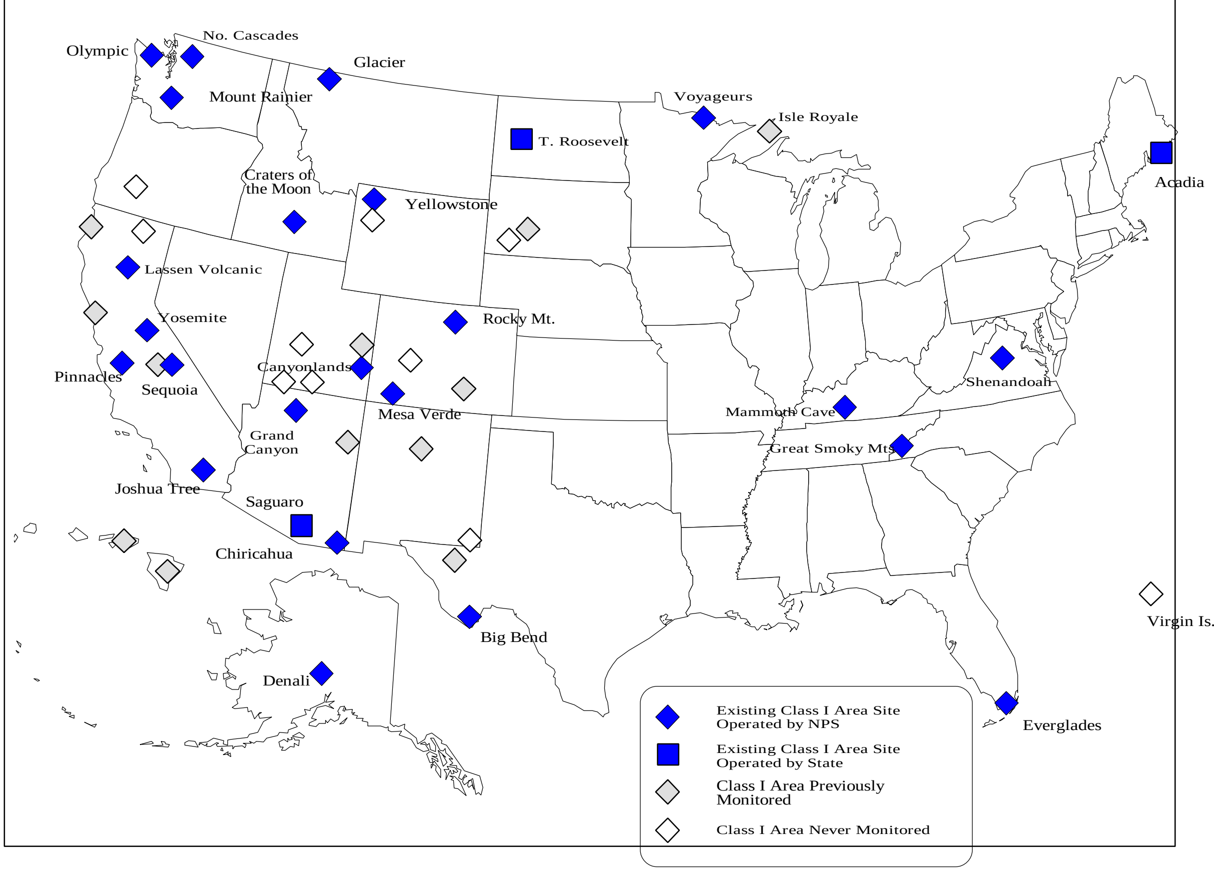


Figure 1 Map indicating which of the 48 NPS Class I have ozone monitoring. These Park Service units are to get the most protection of air resources under the Clean Air Act.

The table below lists the type of monitoring, the number of parks involved, and the overall number of sites. In most cases monitoring equipment is co-located within a park when more than one type of measurement network is involved. The most expensive and difficult network to operate is the continuous analyzer network of gaseous monitors.

	Gaseous Monitoring (continuous)		**Integrated Sampling Methods (SO2)**	**Dry Deposition Network**	**Wet Deposition**	**Enhanced Monitoring**	**Passive Ozone Sampling**
	O3	**SO2**					
Parks:	25	2	27	19	23	3	18
Sites:	33						20

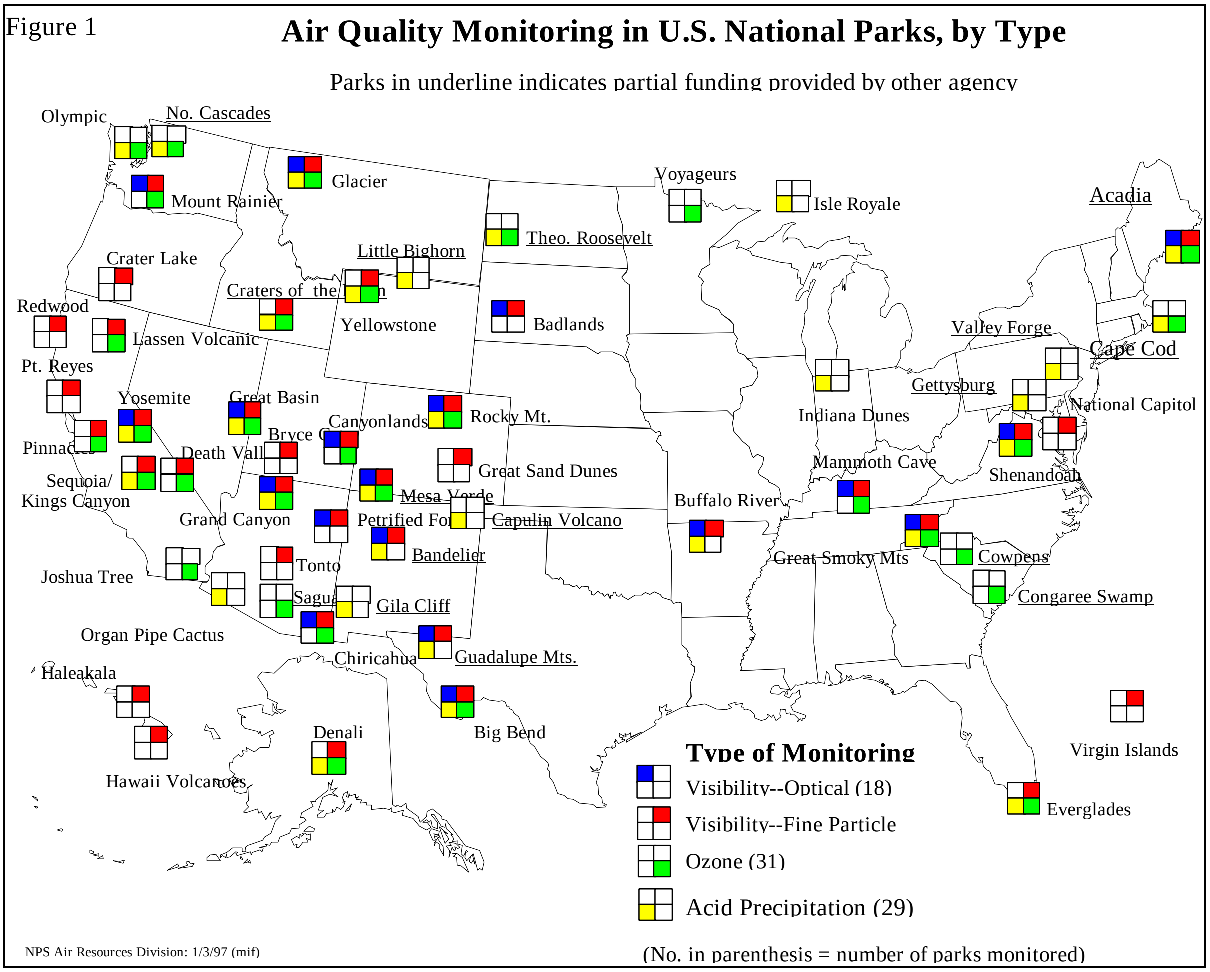


Figure 2 There are three interlocking air quality networks (gaseous pollutants, visibility, and acid deposition) within the Park Service. This map indicates what air quality monitoring is present in the parks.

Uses and Reporting of Data

The air quality data is used internally to support resource studies, permit evaluations, interpretative projects, and efforts to determine trends and effects. Some of the reports and other uses include:

- Annual data summary reports
- Data submittals to EPA's AIRS database for use by States, EPA, and researchers
- Replies to direct data requests
- Publications:
    - Regional air quality reviews
    - Commission reports
    - NPS reports distributed internally
    - Peer-reviewed journal articles
    - Journal articles by other researchers
    - Air Quality in the National Parks report

Comparison of Ozone in NPS Parks to National Standards

Several park units are currently in non-attainment areas based on the EPA National Ambient Air Quality Standard of more than one exceedance per year of the hourly average concentration of 0.12 ppm including: Sequoia-Kings Canyon, Yosemite, Joshua Tree, Pinnacles, Santa Monica Mountains, and Indiana Dunes. The number of annual exceedances is quite variable due to the annual differences in weather and climate.

Recently EPA proposed some new concentrations-based primary and secondary ozone standards. A number of park units are likely to be classified as non-attainment based on the proposed standards including: Sequoia-Kings Canyon, Yosemite, Joshua Tree, Pinnacles, Santa Monica Mountains, Indiana Dunes, Acadia, Cape Cod, and Great Smoky Mountains. The map below shows the projected non-attainment areas.

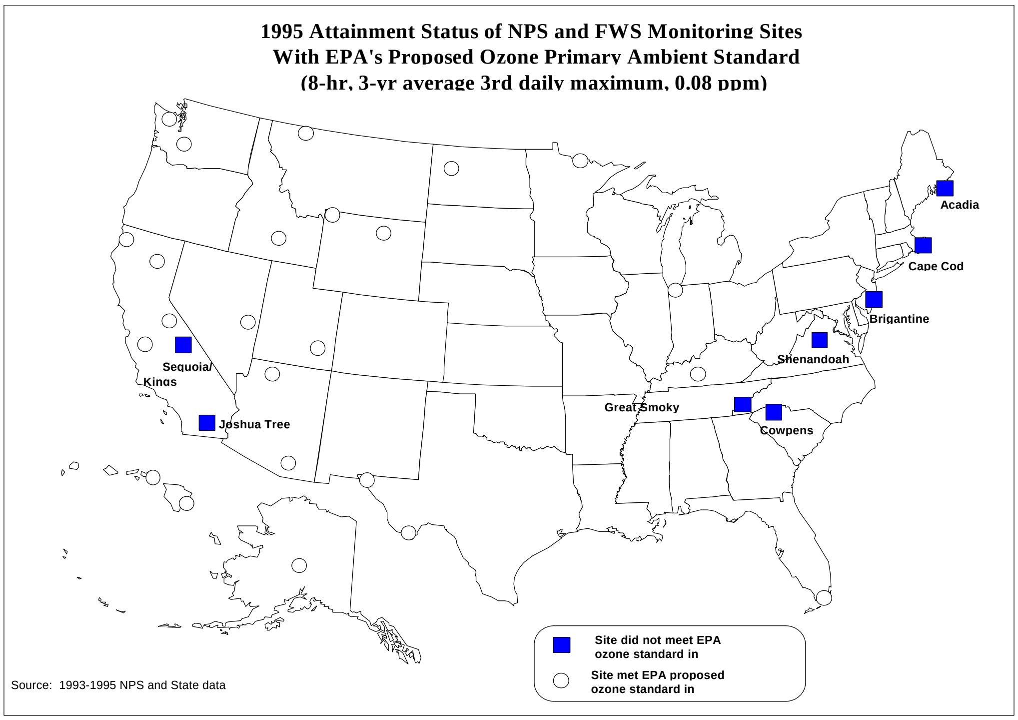


Figure 3 In 1997, EPA set a new National Ambient Air Quality Standard for ozone. Based on historical data from the NPS monitoring network, the 8 parks with solid square symbols on the map are likely to exceed the standard. The East coast states and Southern California have poor air quality even at these rural park locations.

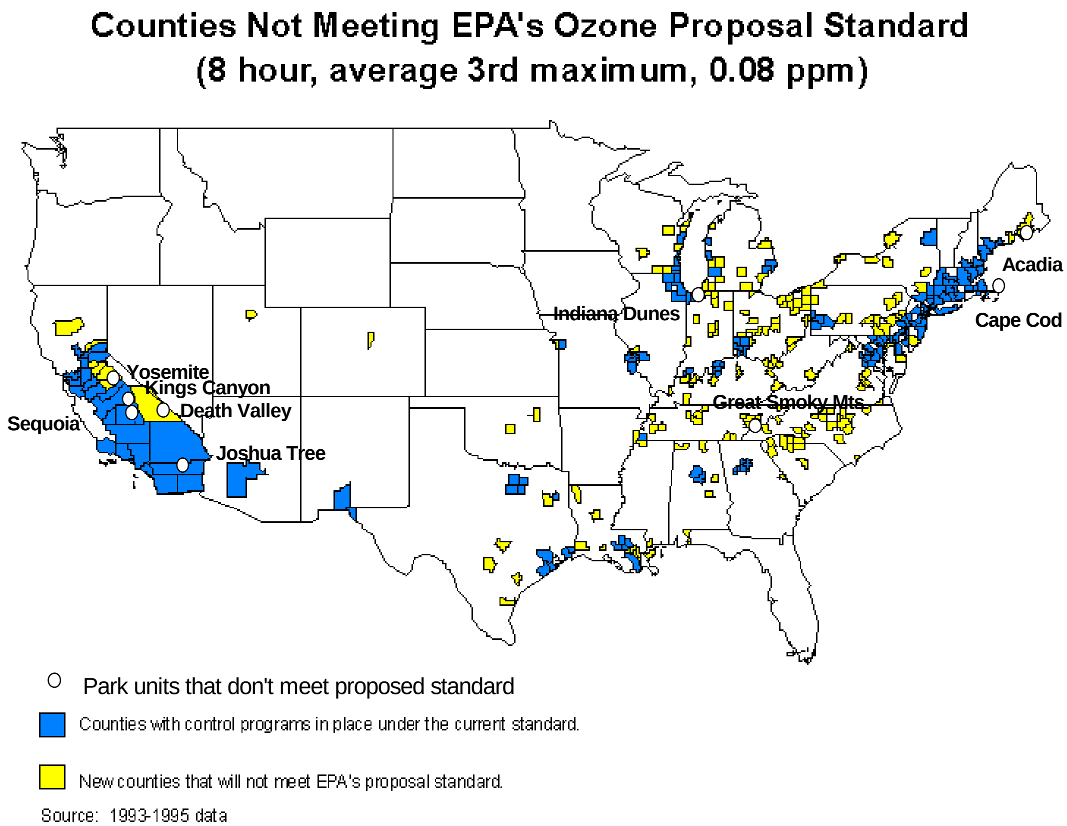


Figure 4 Prior to setting the new 8-hour average NAAQS standard for ozone, EPA looked at historical data and determined that the counties in color on the map would not meet the proposed standard. Park Service units are marked on the map for reference.

Trends for Pollutants in Parks

Although a few parks have seen slight decreases in ozone concentrations (Acadia, for example), most parks have seen little change or some increases in ozone. The principle areas of high ozone are southern California and the Eastern parks. Large annual variations due to changing meteorology tend to hide small changes in ozone concentrations. Sulfur dioxide concentrations, on the other hand, seem to be going down in the East. Decreases in sulfur dioxide annual mean concentrations of 15-20% have been observed.

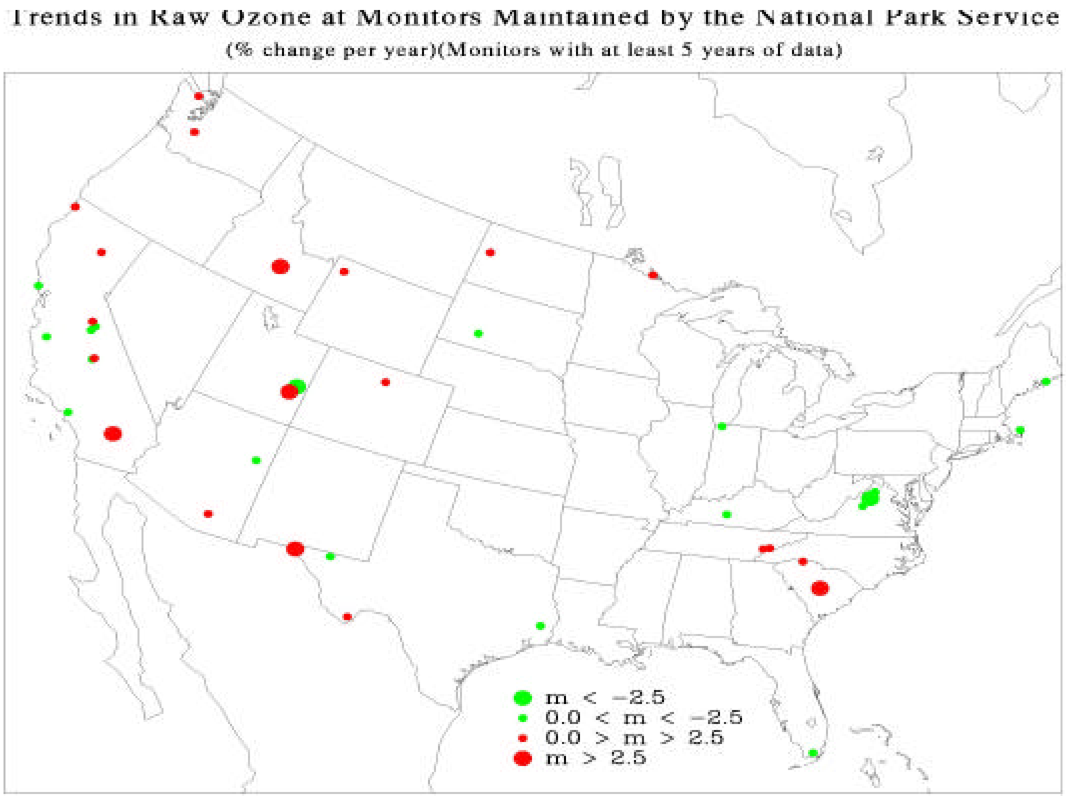


Figure 5 Trends in ozone can be very difficult to determine. Rao, et al. analyzed NPS monitoring data and arrived at the estimated indicated on the map by the size and color of the spots. No correction was applied to the trend analysis for changing in climate during the 5 year data period.

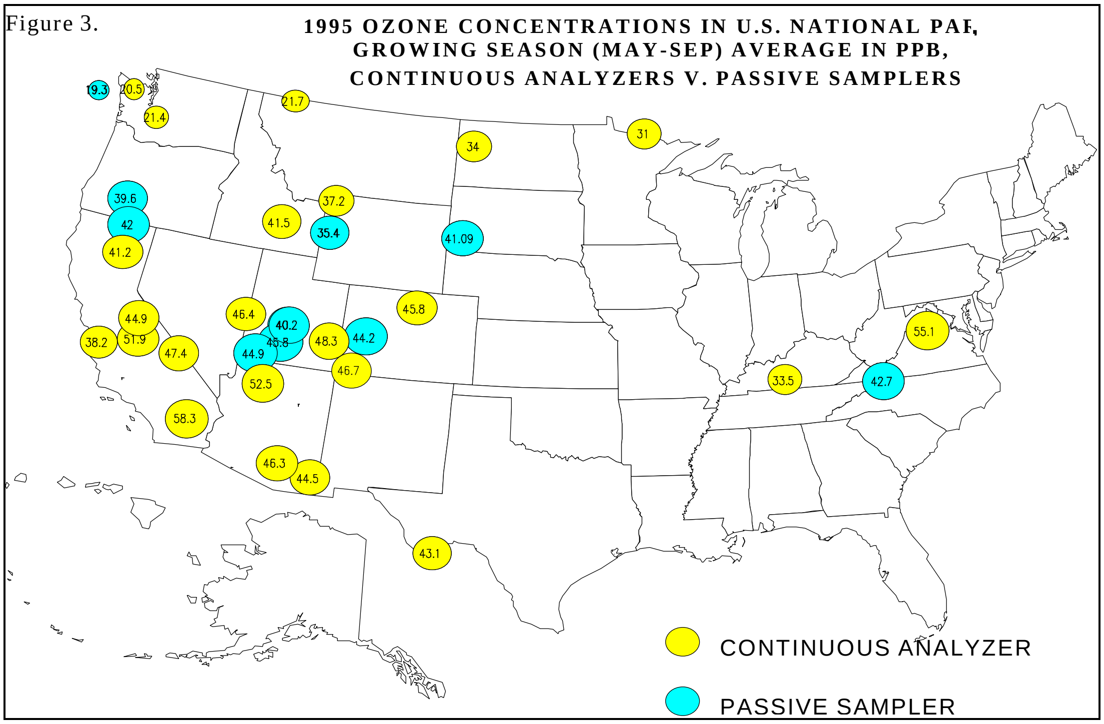


Figure 6 The circles on this map are proportional to the mean seasonal ozone (in ppb) for the park units at those locations. The blue circles are passive sampler data for ozone. The passive sampler locations have ozone averages well below the averages for parks where the NAAQS standard is exceeded (for example, Sequoia at 51.9 ppb or Joshua Tree at 58.3 ppb).

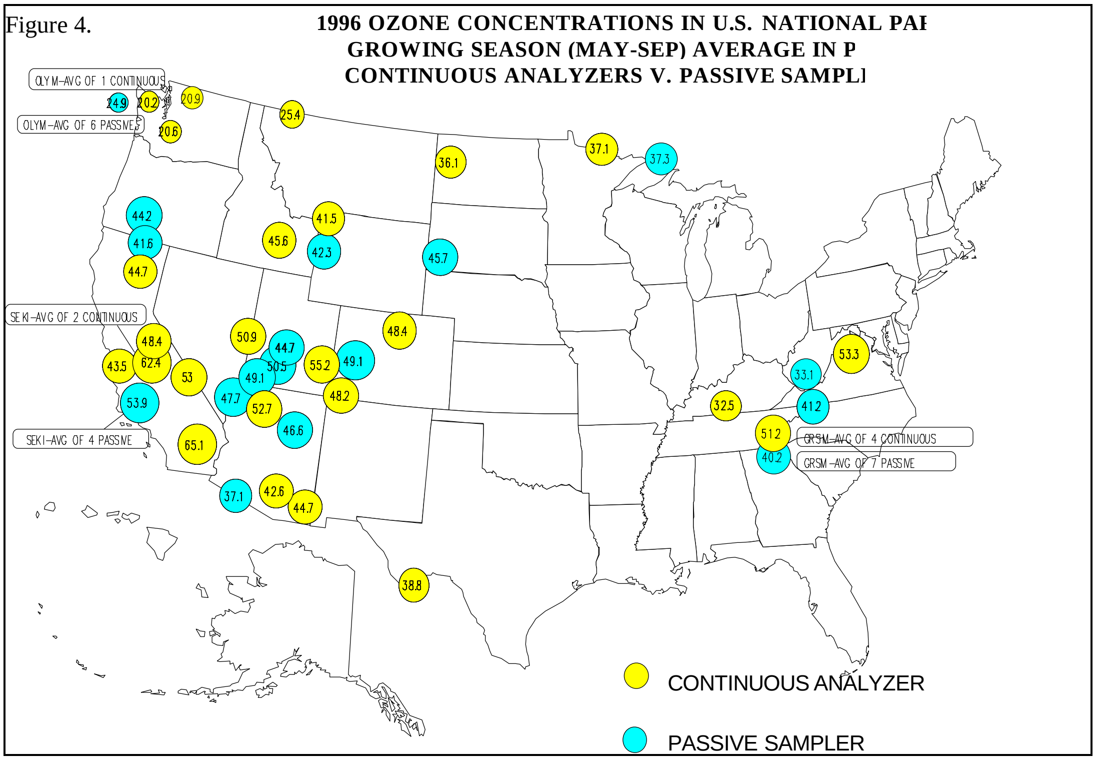


Figure 7 The circles on this map are proportional to the mean seasonal ozone (in ppb) for the park units at those locations in 1996. The larger number of passive sampler locations (blue circles) fill in the gaps in ozone data for Class I Park Service units.

Enhanced Monitoring and Special Studies

The measurement of ozone precursors and additional parameters is important to understand the chemistry and transport of ozone. In three National Parks (Shenandoah, Great Smoky Mountains, and Mammoth Cave) enhanced monitoring with research-grade instruments is being conducted in cooperation with regional ozone studies. Enhanced monitoring support effects research, helps identify pollutant sources regions, provides information to evaluate new source permits, and supports research on what methods of pollution control would best reduce ozone concentrations.

Other studies are supporting specific objectives, including the US-Mexico border study to look at SO2 transport to Big Bend National Park from power-plant sources in Mexico and the passive sampler for ozone that provides ozone spatial distributions and baseline information in parks that have not previously had any ozone monitoring.

Passive Sampling Program

Passive devices for the measurement of ozone concentrations were tested by the Air Resources Division to determine their accuracy and suitability for use in locations where AC line power is unavailable. These simple devices are inexpensive and easy to use, thus, enabling studies of the spatial distribution of ozone within a park or over a region what few continuous ozone monitors are available. A sampling network in primarily Class I areas was established to measure week-long ozone concentrations during the summer time ozone season.

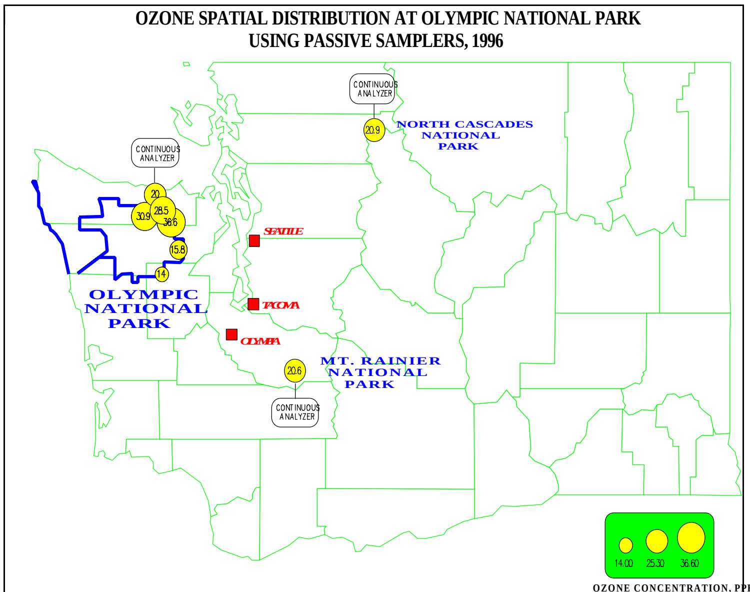


Figure 8 The seasonal average ozone concentrations for multiple passive sampler sites in Olympic National Park shows the large spatial variability of ozone in complexterrian. Elevation and location relative to pollutant source regions can effect the ozone doses seen by the natural resources.

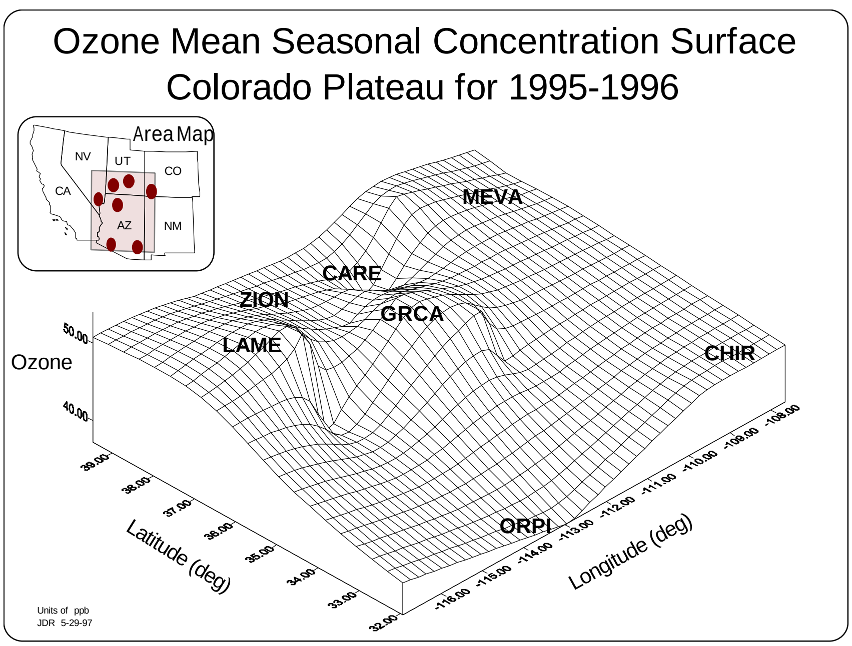
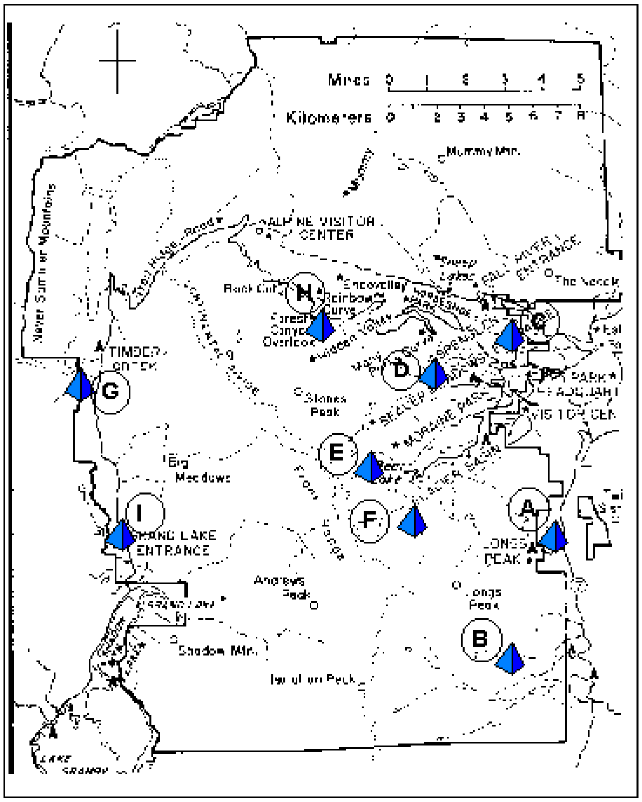


Figure 9 Data from continuous and passive sampler monitoring sites was combined to estimate the regional ozone concentrations for the Colorado Plateau. This interpolation surface gives an interesting view of the seasonal average ozone concentrations.

Rocky Mountain National Park



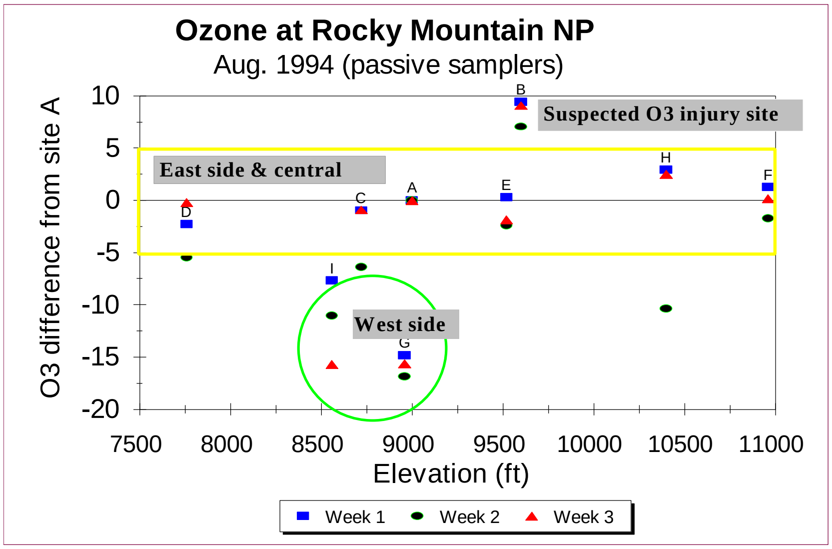


Figure 10 a) The passive sampler locations for Rocky Mountain National Park are indicated on the map. b) The ozone concentrations observed were plotted relative to the continuous ozone analyzer on the eastern edge of the park (site A). A significant difference is seen betweenthe the east and west sides of the mountains. The eastern side of the park gets pollution from the Denver metropolitan area transported the 20-40 miles up to the park.

Network and Research Needs

The present monitoring network has seen decreased funding in recent years that has lead to reductions in the number of monitoring sites, inability to replace aging and dated equipment, limitation on monitoring ozone in all of the Class I areas, and reductions in quality assurance programs. An initiative is needed to support monitoring in the remaining Class I areas, to strengthen the present monitoring effort, and to assistant in more data analysis and interpretation.

Prepared by John D. Ray, Miguel Flores, and David Joseph of the NPS Air Resources Division, Monitoring and Research Branch.

References:

Rao, S. T., I. G. Zurbenko, R. Neagu, P. S. Porter, J. Y. Ku, and R. F. Henry, Space and Time Scales in Ambient Ozone Data, *Bull. Am. Meteorological Soc*., 78, 2153-2166 (1997).

Rao, S. T., Private Communication, 1997

Mon network overview.doc
JDR 3-5-98 Ver. 1.2